Space Weather Technical Forecast

Issued on Thursday, 30 March 2023 at 12:08 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of both Minor/Moderate Radio Blackouts and Minor Geomagnetic Storms to end current week. Initial Active electron fluence moderating for a time, perhaps recovering into new week. CME(s) pending assessment.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with occasional M-class flares measured at GOES16 and 18 peaking with an M5.4 at 30/0737UTC from the largest and most active group on the disc, AR3256 near the southwestern limb. This event was tied to both Type II and IV radio bursts, with the former associated with an estimated speed of 369km/s. The resulting Coronal Mass Ejection (CME) is now becoming visible on Lasco C2 and will be analysed in due course, however tentatively it lies quite westward for any Earth-based geomagnetic effects. In terms of precursor activity, AR3256 also produced an earlier M1.2 at 29/1407UTC, and an M1.1 at 29/2346UTC. This group was one of eight surviving on the disc by the period's end, and was undergoing apparent areal decay at this time in its central regions especially, however the narrowing viewing angle is now very likely hiding developing detail in its current Fso/beta appearance.

By comparison, the remaining seven numbered regions were smaller and simpler, with only AR3262 showing any growth in developing some trailing spots to the south of the main penumbral group.

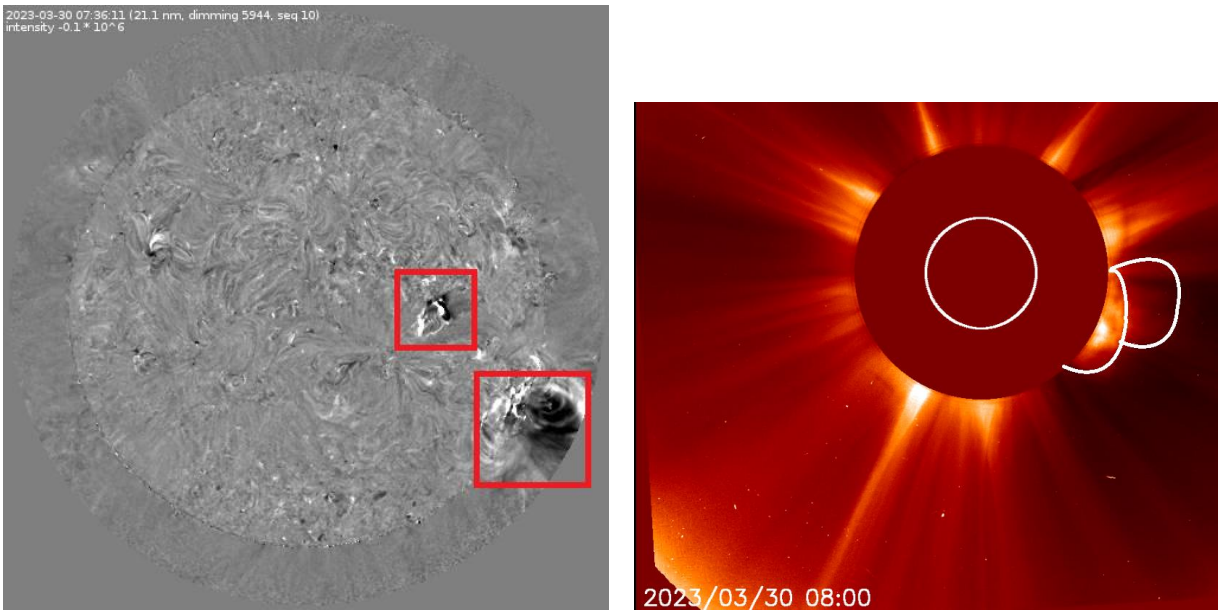

Figure 0: Time-integrated AIA211 dimming of the M5.4-related CME and perhaps a second smaller event at 30/0720UTC nearer centre-disc. It is possible both are now showing on coronagraph

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imagery and will be analysed in due course. Image processing courtesy of SIDC ROB.

At the very start of the 24-hour reporting period, a large southeastern limb-straddling prominence lifted, peaking around 29/1230UTC. The resultant ejecta has been analysed and shows no Earth-directed component. Also of note was a dimming and possible subsequent small CME from near the solar equator around 40W at 30/0720UTC. This feature may just be discernible on coronagraph imagery before it becomes swamped by the later and larger M5.4 event. This will be analysed shold imagery allow.

At the time of writing, no Earth-directed CMEs feature in the forecast, with the caveat that the M5.4 CME and the event immediately prior have yet to be analysed.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by DSCOVR, was initially typical of a slow regime, with a transition into either a CIR (likely leading CH88/-), else a weak passing transient (shock) then taking place almost exactly around the turn of the current UTC day.

A small discontinuity in many solar wind measures was observed at L1 at 29/2359UTC, with a possible analogue seen at STEREO A MAG and PLASTIC at 29/2319UTC. Should these events be linked, tentatively a weak transient arriving from the eastern solar hemisphere would perhaps be more likely than the otherwise-expected CIR, although this is not a definitive cause.

The solar wind speed was initially Slightly Elevated at around 400km/s, jumping to near 475 around 00UTC and remaining within the high-400s of km/s thereafter. The solar wind density started in single figures ppcc, but rose to nearer 10 by the period's end, with the gradual onset perhaps more supportive of a CIR - the main detractor in terms of evidence for any CME. The IMF was initially stable below 9nT with a slowly varying north-south component between +/-5nT, becoming dented in the current UTC day before a gradual recovery, while the Bz component became more generally anti-aligned with Earth's field. Finally, the phi angle was negative (towards the Sun) throughout, but with a slight change of character after 00UTC.

The net result of the above solar wind measures was for Quiet to Unsettled geomagnetic activity, peaking with a provisional Kp '3o' in the 00-03UTC interval.

Energetic Particles / Solar Radiation: A high energy proton enhancement (greater than 10MeV) is now visible at GOES16 in the wake of the 30/0737UTC M5.4 flare, however thus far the magnitude of the rise is considered modest (and comfortably sub-S1), with 10MeV protons peaking at roughly half a pfu by mid-morning UTC (where S1 is 10pfu).

The high energy electron flux (greater than 2MeV), as measured at GOES16 fell from High to Normal Background in the wake of Unsettled overnight UTC geomagnetic activity, falling from a peak of 3870pfu at 29/1255UTC. The associated 24-hour fluence initially rose slightly above the Active (1e8 integrated pfu) threshold, recording 1.81e8 integrated pfu at 30/0001UTC before moderating a little into the current UTC day.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Chance of further M-class flares in the next 36 hours or so, most likely from AR3256 in the southwest. The risk of further such events should then fall into the coming UTC weekend as this region departs.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs currently feature in the forecast. Coronal hole 88 is due to arrive within the current UTC day, giving a Chance of G1 to end the current UTC week before moderating through the weekend to leave mainly Quiet conditions

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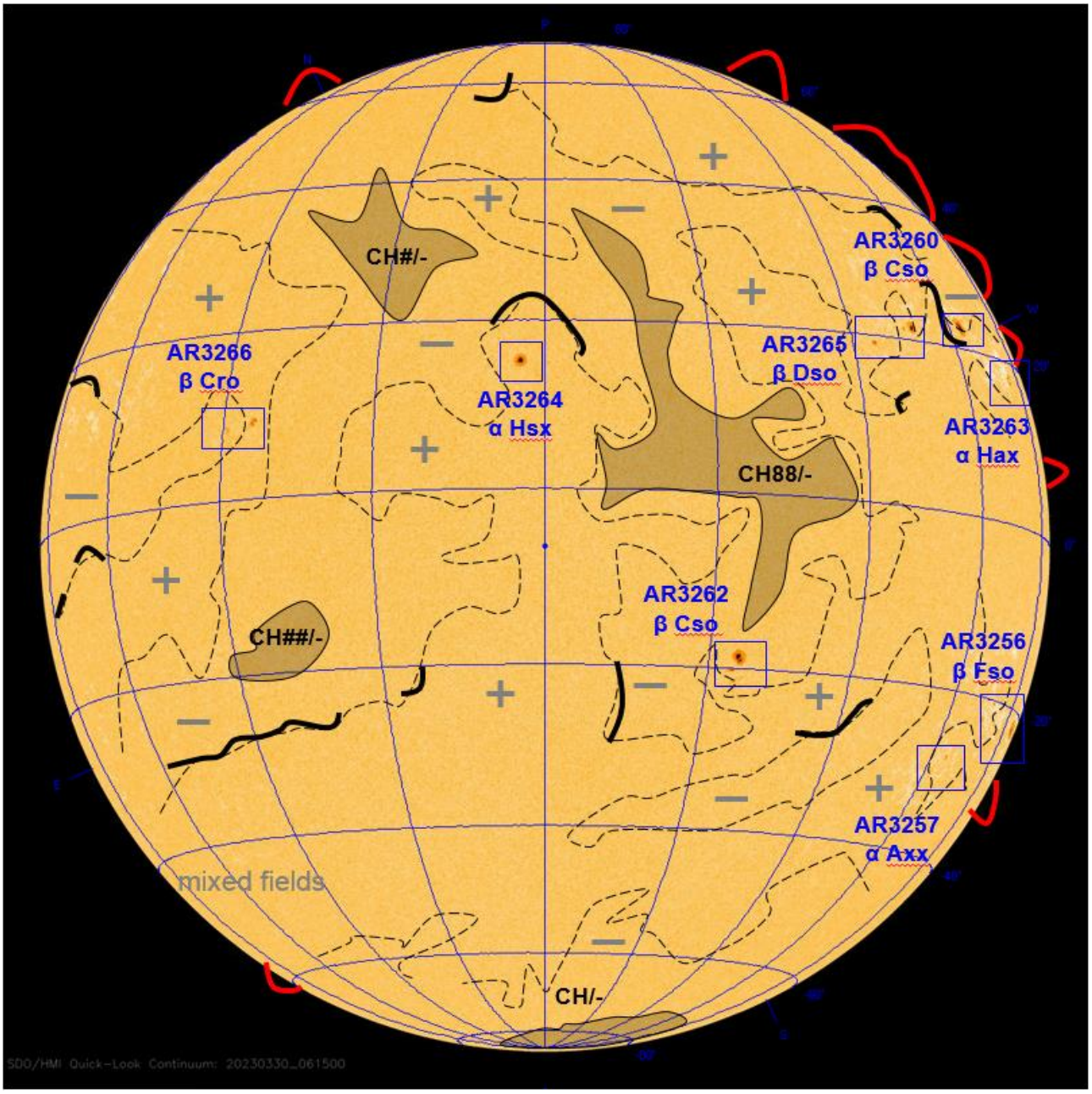
ahead of the UTC day of Monday 03 April.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux carries a now-raised Slight Chance of breaching S1 given recent enhancement and the prospect of the active region responsible remaining in a geoeffective location through this forecast period.

The high energy (greater than 2 MeV) electron flux should be attenuated at GEO below diurnal High peaks in the near-term. This is then Likely to be restored by the end of the four-day forecast, such that 24-hour Active fluence should become Likely by day four, Sunday 02 April.

Figure 1. Solar Analysis Valid 30/0615UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No CMEs feature in the current forecast. See the 'Solar Activity' section for further details.

Solar wind have undergone a recent slight enhancement in the current UTC day - the cause of which is not certain, but perhaps slightly favours a weak transient shock if the STEREO A signal is part of the same feature. This should therefore give way to a CIR leading CH88/- inside the next 12 hours or so. The coronal hole responsible appears slightly further west than the previous rotation to perhaps put arrival within the current UTC day, with speeds likely to reach 500-550km/s. This feature should have largely passed by the end of the coming UTC weekend, ahead of largely Quiet conditions restored into the following working week.

There is a Chance of Minor Geomagnetic storm G1 in the next 48 hours, probably slightly biased into day two, Friday 31 March given the probable late onset within the current UTC day. The risk of further G1 intervals should then fall as the feature matures, such that Quiet conditions should predominate ahead of the new week.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	40	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Radio Blackouts - X-Ray Flares:

Having crossed nearly the entirety of the front side of the disc as a nominally potent but under-performing region, AR3256 has sparked into life in the past 36 hours or so. The narrowing viewing angle is now severely hampering analysis, but there appears to have been an overall areal decrease in this spot group, with some of the central portion fading. This is very likely to belie some development elsewhere given recent occasional M and isolated X-class flare activity. The group itself currently manifests as an Fso/Beta.

This is by far the most active group on the disc at present, although a lot of the current cohort are now nearing the western limb and are all to some extent suffering the same problem with limb foreshortening in terms of analysis. Of the eight regions, only Ar3262 showed any growth, with minor trailing spot development.

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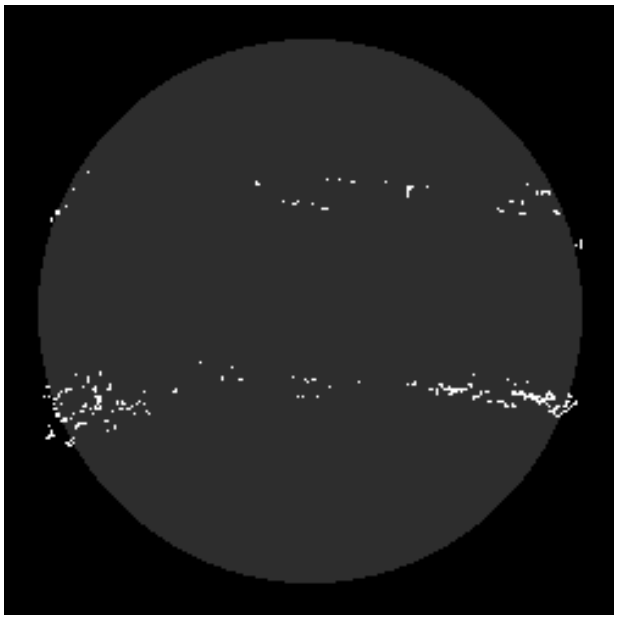
The risks of M and X-class flares have been revised significantly upwards relative to recent guidance, on the assumption that the disc as assessed is hiding detail in AR3256 in particular. There is a daily Chance of M-class flares and a Slight Chance of X for the next 36 hours or so, whereupon AR3256 should leave the Earth-facing disc and the probabilities should moderate into the coming UTC weekend.

The character of the returning Carrington locations for up to six past regions that may return in the four-day period has yet to be determined, and any slowing of the otherwise declining risk will be considered when these become analysable.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	50	50	25	25
Very Active	R3 to R5 X	No	15	15	1	1

Figure 2: Locations of X-ray flares of C-class and above in the past fortnight, with processing by SIDC ROB. Note the intensification of the southwestern swathe of flare activity in more recent days – largely the result of a resurgent AR3256. Fortunately, its passage of the central disc was quieter.



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Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES16 is currently in the process of responding to the radiation emanating from the 30/0737UTC M5.4 flare. This appears to be a soft response so far, with a gradual comfortably sub-S1 rise in 10MeV at the time of writing, and with 50MeV and 100MeV little changed.

The relative chances of S1 have been revised upwards to account for a resurgent AR3256 near the best-connecting western solar horizon of the Sun in the period, although given the modest magnitude this still only peaks at a daily Slight Chance. Once AR3256 crosses onto the far side, the risk is expected to gradually decrease once again.

Radiation Storms **Probability (Exceedance)**	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** **(%)**	**Day 2 (00-24 UTC)** **(%)**	**Day 3 (00-24 UTC)** **(%)**	**Day 4 (00-24 UTC)** **(%)**
Active	**≥ S1**	No	20	20	15	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Past 24 hours in GOES 16 high energy protons and X-ray flares, showing the soft response to the M5.4 to half a pfu at 10MeV. While this may rise further, S1 is not expected as a result of this event.

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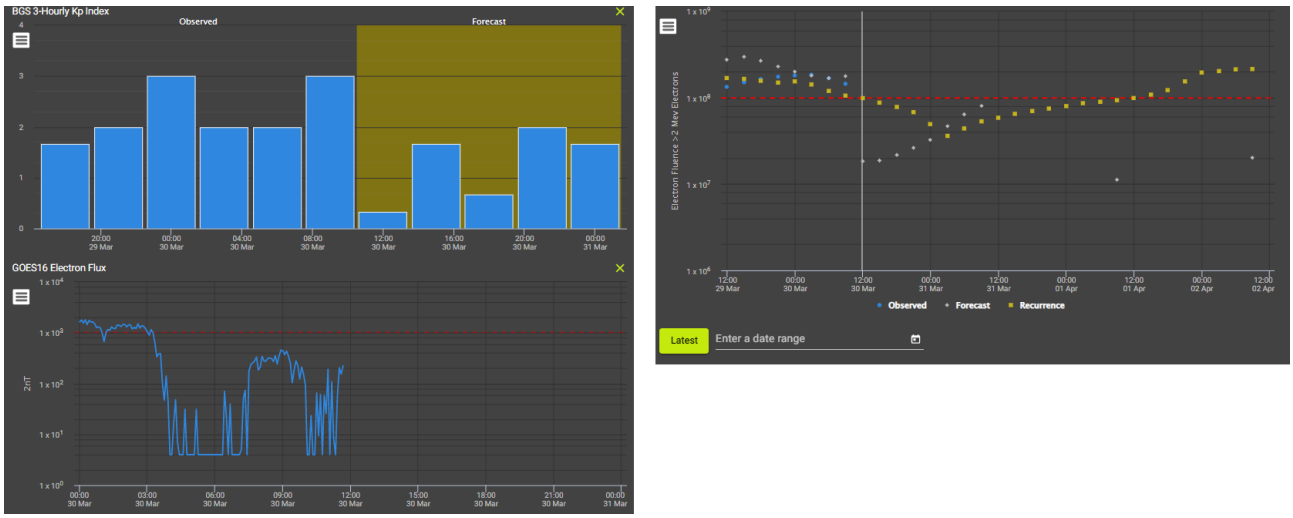
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux recorded by GOES16 at GEO was dented in the wake of minor geomagnetic activity in the past UTC night, such that continuation of the current 24-hour integrated Active conditions is now less assured. This is especially true as the CIR and eventual CH88/- fast wind should bring with it yet more geomagnetic activity that may serve to further reduce fluence levels.

Current levels are Likely to fall within 24 hours, remain sub-Active for a period, before Likely returning to exceed 1e8 integrated pfu before the UTC weekend is out, as geomagnetic activity reduces.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	Yes	100	30	40	70
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: BGS three-hourly Kp indices (actuals un-shaded); GOES16 high energy electron flux (below); and MOSWOC REFM and observed 24-hour integrated fluence (right). The restoration of the fluence after a dip is currently felt to be good guidance, i.e. the persistence trend is accepted, even if the forecast graph is more muted.



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